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Combining Ability of *Gossypium hirsutum* L. Parents for Seed Oil Content

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Abstract
The mean squares obtained from the analysis of seed-oil content of cotton (*Gossypium hirsutum* L.) genotypes showed that effects of general combining ability and specific combining ability and of reciprocals were significant. However the larger proportion of variance was resulted from (gca) effects, indicating that additive genes were predominant in the inheritance of the character. The results suggest that there is a potential for improving oil content in *hirsutum* species and rapid progress may be made by following pedigree selection method. The comparison of the parents indicated that 'NIAB 78', B 557' and 'Acala 1517' were the best general combiners for oil content. The performance of the parents in their specific combinations suggest that it is not necessary always that good general combiners give good hybrids, sometime parents with low or poor GCA may have the potential to give promising hybrids. The combinations 'NIAB 78' x 'B 557', 'NIAB 78'x'Acala 1517 A' and 'B 557' x 'Acala 1517 A' had higher values than other crosses for oil content.

Introduction
Cotton (*Gossypium hirsutum* L.) in addition to giving fibre, its seed is a big source of edible oil. in Pakistan cotton seed oil contributes about 72 percent of the total oil production (Khan *et al*., 1995). Despite being the dual purpose plant, this aspect of cotton plant remained unexploited because the breeders had focussed all their attention on improving cotton yield with good fibre properties. It is in the recent years owing to increasing demand for edible oil, the cotton breeders have developed breeding programme to exploiting the genetic resources for getting more benefits from cotton plant through seed oil.

The information reported in the literature revealed that variation in oil content existed within hirsutum species (Bhale *et al*., 1989; Dani, 1989; Khan *et al*., 1995). However information on the genetic mechanism of oil content is not reported, the fewer studies showed that oil content is heritable in nature and genes showing additive and non-additive properties influenced the character (Wang and Li, 1991; Dani, 1991, 1993; Zhu *et al*., 1995). Varghese *et al.* (1995) reported the occurrence of significant and positive heterosis for oil content in some of the hybrids studied, suggesting that overdominance effects of genes were important for the character. In view of non-evailability of much information about genetic behaviour of oil content in cotton seed, the present study has been planned to generate genetic information for improving cotton as well as its oil.

Materials and Methods
This study was conducted on cotton during 1995-96 in the experimental area of the Department of Plant Breeding and genteics, University of Agriculture, Faisalabad. The genetic material used was developed by crossing 4 indigenous cultivars, '268F' (a tall, bushy cultivar developed in 1948, obsolete now-a-days), 'B 557' (a tall, bushy variety developed by crossing '268F' x 'L5'), 'MNH93' (medium variety with big bolls, a selection from population of double cross ('124F' x 'Babdel') x ('MS39' x 'Mex12') and 'Niab 78' (a dwarf mutant developed by irradiating F, seed of 'AC134' x 'DPSL16'), to four exotic lines namely' paymaster ill', Lankart', 'Dunn 56A' and 'Acala 1517A' (all introductions from USA). These eight parents of cotton are distinguishable for yield and other agronomic plant characters and were selected on the basis of differences and similarities in oil content tested in the laboratory (Khan *et al.* 1995). Diallel crossing system was adopted for hybridization and all the 56 crosses were made using hand-emasculation. The seeds of all the crosses along with their parents were planted in 3 replicates following randomized complete block design. Each of the 64 families was sown in single row plot having 10 plants spaced 30 cm within a row and 75 cm between rows. At maturity seed-cotton of central 8 plants in a row were picked, one plant on either end was left as guarded plant. The seed-cotton was ginned to obtain seeds for oil analysis.

To determine oil-content, a sample from seeds of each plant in a family was taken, delinted and dried; replicated thrice. For estimation of oil, Wide Line Newport Nuclear Magnetic Resonance Analyser was used. The mean values of oil content of each genotype were obtained for genetic analysis. Combining ability analysis of the F, data was made following Griffing technique (Griffing, 1956).

Results and Discussion
Means of oil content of 8 parents and 56 hybrids are given in Table 2. In the parents oil content varied from 18.25 percent in '268F' to 24.53 percent in 'Acala 1517A'. In the hybrids (direct crosses) mean values of oil content ranged from 18.52 percent to 23.98 percent, whilst reciprocals differed from each other with a minimum 18.36 percent and maximum 23.66 percent oil content in cotton-seed. Analysis of variance of the data revealed that all the genotypes were significantly different ($p<0.01$) from each other for oil content in cotton seed (Table 1). Therefore combining ability analysis of the data was

Table 1: Analysis of variance and combining ability of seed oil content in 56 F_1, hybrids and eight parents of *Gossypi hirsutum* L.

Source of variation	d.f.	Sum of squares	Mean squares	Variance ratio	Variance %age (5^2)
1Blocks	2	8.11	4.06	58.77**	
Genotypes	63	620.59	9.85	142.75**	
(gca)	7	171.10	24.44	1062.61**	67.50
(sca)	28	30.84	1.10	47.82**	27.74
(red.)	28	4.93	0.18	7.83**	3.70
Error	126		0.07 (0.02)		1.06

**, denotes differences significant at $p<0.01$

Table 2: Performance of eight parental lines for their gca, sca and in reciprocal combinations for seed oil content in hybrids of *Gossypium hirsutum* L.

Genotypes Parent	Means of oil content	Estimates of gca	Estimates of sca	Estimates of reciprocals
'Niab 78'	23.93	1.50		
'B557'	22.28	1.08		
'268F'	18.25	-1.01		
'MNH 93'	18.94	-0.76		
'Paymaster III'	19.16	-0.79		
'Lankart'	20.06	-0.54		
'Dunn 56A'	19.70	-1.11		
'Acala 1517A'	24.53	1.65		
cd_1 (g_i-$g_{j'}$)		0.11		
Cross combination				
'Niab 78' x 'B557'	23.67 (23.22)*		0.09	0.23
'Niab 78' x '268F'	20.76 (20.64)		-0.57	0.06
'Niab 78' x 'MNH 93'	22.12 (22.31)		0.07	-0.10
'Niab 78' x 'Paymaster III'	21.92 (21.84)		0.39	0.04
'Niab 78' x 'Lankart'	21.82 (21.47)		-0.09	0.18
'Niab 78' x 'Dunn 56A'	20.88 (20.34)		-0.56	0.27
'Niab 78' x 'Acala 1517A'	23.98 (23.66)		-0.10	0.16
'B557' x '268F'	22.50 (20.23)		-0.53	1.14
'B557' x 'MNH 93'	21.32 (21.37)		0.25	-0.03
'B557' x 'Paymaster III'	20.77 (21.42)		-0.01	-0.36
'B557' x 'Lankart'	21.44 (21.28)		0.05	0.08
'B557' x 'Dunn 56A'	20.51 (20.74)		-0.12	-0.12
'B557' x 'Acala 1517A'	23.50 (23.45)		-0.02	0.03
'268F' x 'MNH 93'	19.01(19.11)		-0.05	-0.05
'268F' x 'Paymaster III'	19.08 (19.40)		-0.31	-0.21
'268F' x 'Lankart'	19.38 (19.07)		0.00	0.16
'268F' x 'Dunn 56A'	18.61(18.81)		-0.05	-0.10
'268F' x 'Acala 1517A'	21.53 (21.54)		0.13	-0.01
'MNH 93' x 'Paymaster III'	19.39 (18.63)		-0.22	0.38
'MNH 93' x 'Lankart'	19.12 (19.17)		-0.33	-0.03
'MNH 93' x 'Dunn 56A'	18.97 (18.57)		-0.14	0.20
'MNH 93' x ' Acala 1517A'	21.73 (21.55)		-0.03	0.09
'Paymaster III' x 'Lankart'	19.81 (19.40)		0.16	0.21
'Paymaster III' x 'Dunn 56A'	18.52 (18.36)		-0.44	0.08
'Paymaster III' x 'Acala 1517A'	21.54 (21.37)		-0.18	0.09
'Lankart' x 'Dunn 56A'	19.56 (19.33)		0.32	0.12
'Lankart' x 'Acala 1517A[1]	21.71(21.61)		-0.22	0.05
'Dunn 56A' x 'Acala 1517A[1]	21.07 (21.97)		-0.30	0.05
cd, (S_{ij}-S_{ik})			0.28	-
cd, (r_{ij}-r_{kj})			-	0.30

* The values given in the brackets are of reciprocals.

erformed in order to partition components of variation, ie eneral combining ability (gca), specific combining ability (sca) and reciprocal effects as suggested by Griffing (1956). The results of the analysis revealed that variation oil content was significantly affected by the 3 genetic omponents (Table 1).

The comparison of percentages of each of the components howed that magnitude resulting from effects of gca 67.50%) was far greater than due to sca (27.74%) and iciprocals (3.70%) (Table 1). According to Griffing (1956) ie greater contribution of sca of the parents towards variation in oil content was due to the presence of genes acting additively. The character which appears to be conditioned primarily by additive genetic component is less complex in its inheritance (Liang and Walter 1968, Azhar nd McNeilly, 1988). It would thus seem that variation in oil content in *Gossypium hirsutum* L. is workable and can effectively be exploited to bring rapid improvement.

The previous information on heritability estimates of oil content in cotton-seed is not available and were not calculated from the data presented here. The genetic studies carried out in rape seed (Hu, 1988; Gupta and Labana, 1988) and pearl millet (Bharaj *et al*., 1989) evealed that inheritance of oil content in these crops was controlled by additive genetic effects and estimates of heritabilities varied from moderate to high. Since in the present plant material of upland cotton oil content was controlled by preponderance effects of additive genes, estimates of heritabilities would be high (Falconer, 1981). These results suggest that significant advance in oil content may be achieved by following pedigree selection method, as has already been done in cotton (Singh and Narayanan, 1991).

The comparison of estimates of gca of the parents revealed that 'Niab 78', 'B557' and 'Acala 1517A' showing highest positive values, ie 1.50, 1.08 and 1.65 respectively proved to be the best general combiners for oil content (Table 2). In contrast, '268F', 'MNH93', 'Paymaster III', 'Lankart' and 'Dunn 56A', though all showed their poor gca for the character, the genotypic differences in their gca are discernable. According to Khan *et al*. (1991), the parental lines having good sca were expected to produce good hybrids but here none of the *rect* crosses among 'Niab 78', ' B557' and 'Acala 1517A' yielded combinations of potential value. However me other crosses in which these 3 varieties were involved as one of the parents yielded good hybrids, for example 'Niab 78' x 'Paymaster III', 'B557' x 'MNH93' and '268F' x 'Acala 1517A' which obtained 0.39, 0.25 and 13 numerical values and exhibited best sca for oil tent. In comparison, good sea of 'Paymaster III' x lankartr, 'Lankart' x 'Dunn 56A' has become of great crest to a research worker. In these two combinations both the parents, within the limits of present study, were shown to be poor general combiners but these nicked well and also manifested good sea for oil content.

Similar behaviour of the parents was noted in reciprocal combinations in each of the 3 crosses, ie 'Lankart' x 'Niab 78', 'Dunn 56A' x 'Niab 78', '268F' x 'B557', one good combiner was used as a parent and expressed best sea for oil content. On the other hand 'Lankart' x '268F', 'Paymaster III' x 'MNH93', 'Dunn 56A' x 'MNH93', 'Lankart' x 'Paymaster III' and 'Dunn 56A' x 'Lankart' were shown to be good specific combinations for oil content, though both the parents involved in these crosses appeared to possess poor gca for the character.

Thus the present study suggest that it is not necessary always that good general combiners give good hybrids, sometimes parents with low or poor gca may have the potential to giving promising hybrids. These observations are in agreement of the earlier studies on cotton (Azhar and Akbar 1992). In contrast the cross 'B557' x 'Niab 78' resulting from good combiners expressed best sea and was according to the suggestions given by Khan *et al.* (1991), that parents having good gca always give hybrids of potential value.

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